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(54) Method and apparatus for the production of multiply cellulosic board and product obtained thereby.

(57) A method and apparatus for the production of multiply cellulosic fiber board wherein first and second streams of cellulosic pulp are deposited on a wire, partly dewatered, mechanically integrated and conditioned to form a bilayered web, followed by the deposition of a third stream of cellulosic pulp onto the top of the bilayered web and further dewatering in a flow direction opposite the direction of flow of the dewatering of the bilayered web to hydraulically integrate and form a trilayered web. Preferably, the total quantity of fibers contained in the second (inner) layer is greater than the quantity of fibers in either the first or third outer layers, thereby developing a board product that exhibits an apparent bulk at least equal to the apparent bulk of a single layer board formed from the same quantity of fibers, but containing between about 9% and 11% fewer fibers than such single layered board. The novel product exhibits substantially improved physical and other properties, especially stiffness. Coating of the board with a polymer and formation of the coated board into liquid containers is disclosed.

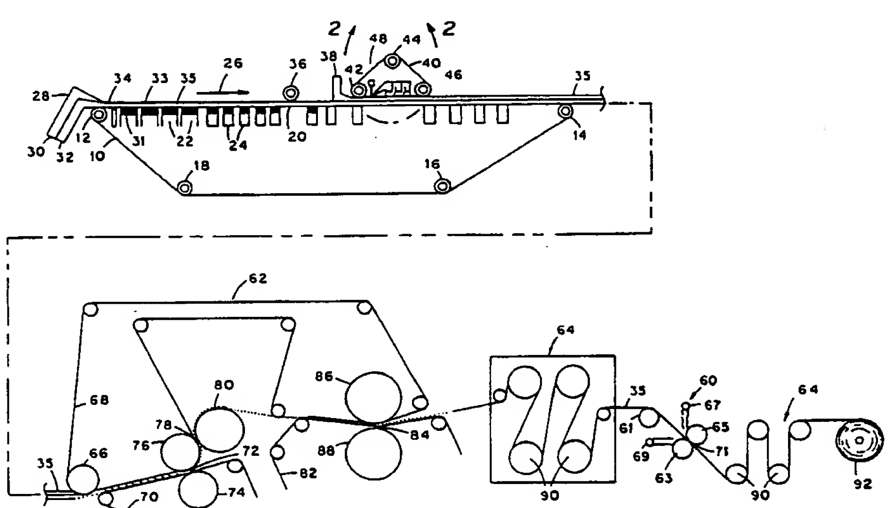

FIG.1

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This invention relates to multiply cellulosic, e.g. paper, board which is particularly suitable for use in the manufacture of containers for liquid food products, and more particularly for disposable milk cartons, and to methods and apparatus for the manufacture of such board.

Disposable containers for liquid food products have long been manufactured from cellulosic board that is formed using conventional fourdrinier papermaking machines. Such board is most usually single ply and of a basis weight in excess of about 150 lb./3000 ft^2. Of recent there has been considerable effort exerted toward producing multiply board for use in such disposable containers in an effort to reduce the overall cost of the board, while maintaining those board properties that are essential for its successful use in disposable liquid food containers. Systems such as those shown in U.S. Patent Nos. 3,681,193, 3,891,501, 4,004,968 and 4,472,244 have been suggested for use in making multiply paper board. In these patents the apparatus and methods disclosed for the manufacture of multiply board, i.e. three or more plies, require complicated and expensive equipment and in most, there is duplication of equipment for developing each of the plies. It is desired therefore that there be a method for producing multiply board of at least three layers which requires less extensive, hence less expensive, modification of existing papermaking equipment and which provides a multiply board having a lessor quantity of fibers in the board, but which provides properties equal or superior to single ply board.

In accordance with the method of the present invention, first and second streams of cellulosic pulps are deposited substantially simultaneously onto a forwardly moving foraminous papermaking fabric, e.g. a fourdrinier wire, to develop first and second layers of a multiply web. These overlaid layers are dewatered to a consistency of between about 1.8% and about 3.5%, by weight, and thereupon are mechanically integrated at their interface and their formation enhanced. Such mechanical integration further conditions the upper surface of the second layer for the receipt of a third layer of pulp. Such third layer is developed by depositing a stream of cellulosic pulp onto the upper surface of the second layer at a location just down-stream of the wet line of the bilayered web on the wire. Substantially immediately following the deposition of such third layer, the three layers are captured between the initial forming fabric and a further formaminous forming fabric that is overlaid onto the top surface of the third layer. Thereafter, the multilayered web is dewatered upwardly through the several layers of the web to hydraulically integrate the second and third layers and enhance the integration of the first and second layers. Thereafter, the web is further dewatered, dried and collected. In a preferred embodiment, the web is dried and fed through a size press prior to final drying to develop a surface size on opposite surfaces of the web, and then calendered. Still further, in the preferred embodiment, the composition of the second layer of fibers includes less expensive fibrous matter, such as a larger percentage of hardwood fibers, and the total quantity of fibers deposited as the second layer preferably is between about 0% and about 300% greater than the quantity of the fibers deposited in forming either the first or third outer layers. In this manner, the apparent bulk of the second (inner) layer preferably is greater than that of either of the first or third layers, but the overall caliper of the board product is maintained at about the same caliper as single ply board made from the same total weight of fibers. The multiply board of the present invention exhibits pertinent properties that are equal to or superior to the same properties of single ply board. Especially, the present board exhibits the modulus, stiffness, bulge resistance, and other properties of a single ply board, and does so with the present board containing between about 9% and 11% less fiber content, by weight.

Further objectives and advantages, as well as understanding of the present invention, will be provided from the following description, including the figures, in which:

Figure 1 is a schematic representation of one embodiment of an apparatus for use in carrying out the method of the present invention;

Figure 2 is a schematic representation of a multiply board in accordance with the present invention and depicting various features thereof; and

Figure 3 shows a turned-up corner portion of a web produced in accordance with an embodiment of the present invention.

With specific reference to Figure 1, there is depicted a preferred embodiment of apparatus for carrying out the method of the present invention and comprises a continuous loop fourdrinier wire 10 which is trained about a breast roll 12, a couch roll 14, and one or more idler rolls 16 and 18. The wire includes an upper run 20 which is supported as by a plurality of suction devices 22 and/or foils 24, all as are well known in the art. The wire is moved in a forward direction, by drive means not shown, as indicated by arrow 26. Adjacent the breast roll 12, there is provided a headbox 28 which in the preferred embodiment comprises two flow channels 30 and 32, each of which is in fluid communication with its respective source of cellulosic pulp (not shown). Pulp streams from the respective channels 30 and 32 are maintained as separate streams until substantially the moment of their discharge from a dual slice 34. These two streams are deposited substantially simultaneously as separate layers of pulp onto the wire 12 as it is moving forwardly to form a

bilayered web 35 on the wire, such web comprising first and second layers, 31 and 33, respectively. In FIGURE 1, the thickness of the layers on the wire 10 are exaggerated for purposes of illustration. One suitable headbox is a Strataflo unit manufactured by Beloit Corporation of Beloit, Wisconsin. As the bilayered web on the wire is move forwardly, it is partially dewatered as by the suction devices 22 and the foils 24. At that point along the length of the upper run 20 of the wire 12 at which the consistency of the fibers in the web has reached a value of between about 1.8% and about 3.5%, the bilayered web is contacted by a dandy roll 36. Such roll 36 preferably comprises an open mesh formed into a cylindrical geometry and positioned with its length transversely of the direction of forward movement of the web. The roll 36 is preferably driven at a tangential speed that is substantially equivalent to the forward lineal speed of the wire, e.g., 100% ± 5%. Further, the roll 36 is mounted so that it can be forced into pressurized contact with the upper surface of the web 35, such that between about 2 to 4 inches of the circumferential dimension of the roll is in contact with the web as the web moves forwardly. This 2 to 4 inch "footprint" of the roll 36 extends across the full width of the web 35. The open mesh character of the roll 36 serves to mechanically engage the fibers of the web and enhance the integration of the first and second layers of the web at their interface as well as enhancing the overall formation of the web. Further, the open mesh smooths and conditions the top surface of the second layer 33 for receiving a further layer of pulp thereon. One suitable dandy roll is formed of phosphor bronze wire having a mesh count of 15 x 13 cm, an open area of about 39.5%, a warp yarn diameter of 0.26 mm, and a weft yarn diameter of 0.25 mm.

Following integration of the first and second layers of the web, and at a location substantially immediately downstream of the wet line of the bilayered web on the wire, a further, i.e. third, layer of pulp is deposited onto the upper surface of the web as from a secondary headbox 38. This headbox may be of conventional single-slice design. The pulp deposited onto the web from the secondary headbox preferably is substantially equivalent in composition and quantity as the pulp deposited onto the wire from the channel 32 of the headbox 28, thereby causing the first and third layers of the web to be substantially identical in a preferred embodiment. Substantially immediately after the third layer of pulp has been deposited onto the web 35, the trilayered web is captured between a further foraminous papermaking fabric 40 which is trained about a plurality of rolls 42, 44, 46 and 48. In a preferred embodiment, such fabric 40 is a part of a device known in the art as a Bel Bond unit, manufactured by Beloit Corporation of Beloit, Wisconsin. The Bel Bond unit includes one or more suction devices 50 disposed on that side of the wire 40 opposite the web 35 and adapted to withdraw water from the web in an upward direction. This action serves to hydraulically integrate the second and third layers of the web, as well as to further dewater the web.

The partially dewatered web is withdrawn from the wire 12 at the couch roll 14 and directed through a wet press 62. In the depicted wet press section 62, the web 35 is first contacted by a suction pick up roll 66 about which there is trained a first felt 68. The web is next captured between the first felt 68 and a second felt 70 and directed through a first press nip 72 between a grooved roll 74 and a suction roll 76. Thereafter, the web, while still on the first felt 68 and trained about the suction roll 76, is passed through a second press nip 78 developed between a suction roll 76 and a hard-surfaced roll 80. Following the second press nip 78, the web is again captured between the first felt 68 and a third felt 82 and conveyed through a third press nip 84 established between a further grooved roll 86 and a smooth roll 88. Pressure loads in the press nips of 200, 300, and 600 p.l.i., respectively, have been found suitable. Other wet press designs known in the art would also suffice.

The web exiting the wet press section is conveyed through a dryer section 64 within which the web is passed over a series of heated rolls 90 and dried. After the initial drying, a water solution or slurry of sizing material may be deposited on the surface of the sheet in a size press 60. Surface sizing further strengthens the sheet surface layer and can include materials that promote a hydrophobic nature of the sheet surface. In the depicted size press 60, the web 35 is fed over a roll 61, then through the nip 71 between a pair of rolls 63 and 65. Sizing solution is fed into the nip 71 from one or both of sources 67 and 69 of sizing solution, depending upon whether one or both surfaces of the web are to receive sizing. From the nip 71, the sized web is fed through a second dryer 64' which includes heated rolls 90'. The dried web may be passed through one or more nips (calendered) to improve surface smoothness. The dry web is collected in a roll 92.

A turned-up corner portion 94 of a web 35 produced in accordance with the present method is depicted in Figure 3. The depicted web comprises a first (bottom) layer 31, a second (inner) layer 32 and a third (top) layer 33. In the depicted web portion, the several layers are delineated for purposes of illustration, but it is to be recognized that the interfaces between layers are not so pronounced in the actual web.

Thus, the preferred embodiment of the method of the present invention comprises the steps of preparing first, second, and third slurries of cellulosic fibers in an aqueous medium, depositing a stream of the first slurry onto a forwardly moving papermaking fabric at a first velocity sufficient to form a first layer of

fibers on said fabric, substantially simultaneously depositing a stream of the second slurry onto the upper surface of the first layer of fibers at a velocity sufficient to deposit onto said first layer between about 0% and 300% greater quantity of fibers from the second slurry than the quantity of fibers deposited from the first slurry, commencing dewatering of the bilayered web and when it has achieved a consistency of between about 1.8% and about 3.5%, mechanically integrating the first and second layers at their interface, depositing a stream of the third slurry onto the upper surface of the integrated bilayered web at a location immediately down-stream of the wet line of the web on the forming fabric, substantially immediately after deposition of the third layer, capturing the web between the first forming fabric and a further foraminous fabric, and withdrawing water from the trilayered web through the further fabric to hydraulically integrate the second and third layers of the web. As desired a surface size may be deposited on the opposite flat surfaces of the web, and the web thereafter dried and/or calendered.

The pulp slurries employed in the present invention are selected to develop first and third outer layers of the present board that capture therebetween a second, i.e. inner, layer which exhibits an apparent bulk that is substantially greater than the apparent bulk of the outer layers. In this manner, the overall caliper of the board is developed with less fibrous content of the board than for single ply board formed from like fibers. In the preferred embodiment, the pulp used for the first and third layers is of the same composition, namely about 75% softwood and 25% hardwood fibers, at a consistency of about 0.8% by weight, based on oven dried fibers and a C.S.F. of about 500. The preferred composition of the inner layer is about 25% softwood and 75% hardwood fibers, at a consistency of about 0.8% and a C.S.F. of about 610. The greater percentage of softwood fibers in the pulp for the outer layers provides for the development of strength in these layers, good surface smoothness of the board product, and other properties. As noted above, the quantity of fibers for the inner layer deposited on the wire is between about 0% and 300% greater than the quantity of fibers deposited in the formation of each of the outer layers. By this means, the inner layer develops an apparent bulkiness which aids in imparting to the board product a final caliper that is equivalent to the caliper of a single ply board, but whose total fiber content is about 9% to 11% less than the fiber content of a single ply board. In this manner, the present invention provides the means for producing more board product with less fibers, and doing so without loss of the desired properties of the board. As the relative volume of the pulp for forming the inner ply varies below about 0% or above about 300% there is a noticeable decrease in the desired properties of the board.

A key property for judging strength of three-ply versus single ply board is stiffness. In the present disclosure, stiffness refers to the geometric mean value of stiffness (square root of the product of machine direction [M.D.] and cross direction [C.D.] stiffness). Stiffness is related to basis weight by the equation:

$$\text{stiffness} = \text{stiffness constant} \times (\text{caliper})^{1.6} \times \text{basis weight} \qquad \text{Eq. 1}$$

or

$$\text{stiffness} = (\text{stiffness constant} \times \text{basis weight}^{2.6})/\text{apparent density}^{1.6} \qquad \text{Eq. 2}$$

Yield improvement is calculated also using these equations, i.e. percent reduction in basis weight that gives equal stiffness. The following Table I shows the average apparent density, average stiffness constant and calculated yield improvement of various boards made in accordance with the present method:

TABLE I

Board Samples	Average Apparent Density	Average Stiffness Constant	Improved Yield %
As-made			
single ply	9.63	0.0048	11.9
three ply	9.47	0.0065	
Surface sized/ uncalendered			
single ply	10.10	0.0066	9.0
three ply	9.84	0.0081	
Surface sized/ calendered			
single ply	11.23	0.0061	8.7
three ply	10.93	0.0074	

Various of the softwoods and/or hardwoods may be employed in the pulps employed in the present invention. International Pine softwood fibers and AO-2 hardwood pulps have been found most suitable, are readily available and similar to pulps produced in the southern United States. In the formation of the pulps, there may be added thereto the usual wet-end chemicals to improve dry strength, improve wet strength, improve retention, alter pH, etc., such as Kymene, Acco-strength 86, caustic for pH adjustment, etc., as desired. Further, tests have shown that the addition of 10% or more of broke to the pulp has no detectable deleterious effect upon the desired properties of the board product. Whereas the consistency of the pulp may be the same for each layer, preferably from about 0.5 to about 0.8%, the consistency of pulp for each layer may be selected to be of a specific value for that layer. The average consistency of the pulps used for formation of the first and second layers (total amount of solids/total flow from both the channels 30 and 32 of the headbox 28) may range from between about 0.6% to about 1.1%, depending upon the desired basis weight of the board product. The pulp consistency employed to obtain a particular basis weight of product is also a function of the wire speed. Table II presents the data from a series of tests employing the present method to produce board product of various basis weights.

TABLE II

Basis Weight (lb/3000 FT [2]	Wire Speed (fpm)	Primary Flow [1] (l/min.)	Primary Consistency[2] (%)
160	1296	4949	.80
180	1161	4140	.92
200	1030	4949	.76
220	938	4780	.83
250	804	4765	.75
282	725	4552	.84
282	705	4491	.87
282	774	4308	.94
282	853	4552	1.02

[1] Total flow from headbox 24
[2] Total amount of solids/primary flow

Board product useful in the manufacture of containers for liquid food products preferably contain a starch size on the opposite outer surfaces of the board. Accordingly, it is preferred in the present method to pass the formed web through a size press containing a conventional starch size to thereby deposit between about 1 and about 3 lb (based on 3000 ft^2) of sizing onto each of the opposite surfaces of the web. In a typical mill run, about 35 lb of starch per ton of fibers, produces a suitable sizing of the web. Other sizes, combinations of sizes, and/or quantities of sizes may be employed to obtain specific results.

The sized web may be calendered as desired.

EXAMPLE I

Multiple test runs using the present method were made to produce both single ply and multiply board suitable for use in disposable containers for liquid food products. In the several runs, the composition of the pulps employed for the several layers of the multiply product and the wire speed were selected to produce different weights of board. All runs were made on apparatus as shown in the Figures and described herein, except that the dandy roll and secondary headbox were eliminated when making the single ply board. The pulp employed in the single ply board was a 50/50 pine to hardwood blend at 610 C.S.F. and 0.8% consistency. Other variables were set as noted in the tables presented hereinafter and in Table II above.

TABLE III

SURFACE SIZED AND CALENDERED SAMPLES

Sample Description - all samples are surface sized and calendered		single-ply controls produced at 0.75 to 0.85% consistency		single-ply controls 0.65% consistency
Basis weight, lb./3000 sq. ft.		186.8	257.9	205.0
Caliper, 0.001 in.		16.7	22.9	17.9
Apparent density, lb./pt.		11.2	11.3	11.5
Sheffield porosity, units/sq. in.		315	256	269
Sheffield smoothness, units	WS	279	286	274
	TS	320	325	315
Taber V-5 stiffness, gm.cm.	MD	146	321	199
	CD	82	175	107
Stiffness ratio, MD/CD		1.80	1.86	1.86
Mean stiff., sq.rt. (MD x CD)		109	236	145
Mean stiff./BS*CAL$^{1.6}$		0.0060	0.0060	0.0068
STFI compression, Newtons/15 mm.	MD	88.9	105.4	109.2
	CD	66.7	87.5	77.5
Tensile, lb./inch width	MD	60.7	76.6	85.2
	CD	42.7	52.4	52.1
Tensile ratio, MD/CD		1.42	1.47	1.63
Breaking length, m.	MD	3557	3259	4563
	CD	2516	2220	2797
Mean brkl.len.,sq.rt.(MD X CD)		2990	2688	3572
Stretch, %	MD	1.84	2.02	2.34
	CD	3.78	4.30	5.01
Tensile energy abs.,ft.lb./sq.ft.	MD	8.34	11.88	15.15
	CD	13.64	19.42	22.75
Extensional stiffness, lb./in.	MD	5508	6553	5872
	CD	2795	3193	3052
Youngs modulus, 1000 lb./sq.in.	MD	330	287	329
	CD	164	138	173
Wet tensile, lb./inch width	MD	9.2	11.33	15.1
	CD	7.8	9.1	11.2

TABLE III (cont'd)

Sample Description - all samples are surface sized and calendered		single-ply controls -produced at 0.75 to 0.85% consistency-		single-ply controls 0.65% consistency
Tensile, % wet/dry	MD	15.0	14.8	17.8
	CD	18.2	17.5	21.5
Wet stretch, %	MD	4.04	4.03	4.75
	CD	6.81	7.27	8.53
Wet TEA, ft.lb./sq.in.	MD	2.95	3.61	5.70
	CD	3.88	4.79	6.78
Wet extensional stiffness, lb./in.	MD	442	596	630
	CD	237	258	252
Internal bond, ft.lb./sq.in.	MD	0.074	0.084	0.092
	CD	0.075	0.084	0.088
Z-direction tensile, ft.lb./sq.in.		27.1	20.7	32.13
MIT fold, number of double folds	MD	138	251	640
	CD	99	244	289
Cracking, % not cracked	TS	100	99	99
	WS	99	98	99
I.G.T. blister, #4 ink, ft./min.	TS	1139	881	1498
	WS	1295	926	1359
Cobb size, 2 min., gm./sq.m.	TS	34	31	29
	WS	35	31	32
Edge abs., 1% lactic acid, 40°F-24 hr.		1.0	1.5	1.2
Edge abs., skim milk, 40°F-72 hr.		1.6	2.4	1.8

TABLE IV

SURFACE SIZED AND CALENDERED SAMPLES

Sample description - all samples are surface sized and calendered		Three-ply Samples		3-ply broke in liners	broke in liners + mid-ply	3-ply 50% mid-ply	3-ply 64% mid-ply
Basis weight, lb./3000 sq. ft.		177.1	246.4	209.3	217.1	278.7	288.6
Caliper, 0.001 in.		16.1	22.6	19.5	20.0	28.1	27.7
Apparent density, lb./pt.		11.0	10.9	10.7	10.9	9.9	10.4
Sheffield porosity, units/sq. in.		136	115	165	169	174	143
Sheffield smoothness, units	WS	277	278	306	291	291	332
	TS	313	285	321	313	315	347
Taber V-5 stiffness, gm.cm.	MD	162	374	254	278	542	582
	CD	82	199	125	121	269	286
Stiffness ratio, MD/CD		1.99	1.89	2.03	2.30	2.01	2.04
Mean stiff., sq.rt. (MD X CD)		115	273	178	183	382	408
Mean stiff./BS*CAL$^{1.6}$		0.0074	0.0075	0.0073	0.0070	0.0066	0.0070
STFI compression, Newtons/15mm.	MD	85.9	111.3	95.0	96.0	116.4	123.6
	CD	62.3	82.9	66.4	73.2	88.8	89.6
Tensile, lb./inch width	MD	67.7	89.3	77.8	72.3	90.9	85.5
	CD	41.7	52.0	44.6	46.0	51.3	50.8
Tensile ratio, MD/CD		1.62	1.72	1.75	1.57	1.77	1.68
Breaking length, m.	MD	4191	3976	4079	3657	3581	3252
	CD	2590	2314	2336	2328	2020	1933
Mean brkl.len., sq.rt. (MD X CD)		3291	3033	3087	2918	2689	2507
Stretch, %	MD	2.05	2.37	2.12	1.84	2.35	2.02
	CD	4.86	4.66	5.54	4.75	4.26	4.31
Tensile energy abs., ft.lb/sq.ft.	MD	10.54	16.16	12.87	10.08	16.43	13.41
	CD	17.70	21.15	21.89	18.51	18.51	18.85
Extensional stiffness, lb./in.	MD	5641	7023	7027	6398	7222	7746
	CD	2644	3010	2588	2021	2440	2746
Young's modulus, 1000 lb./sq.in.	MD	352	311	360	320	257	280
	CD	164	133	132	101	87	99
Wet tensile, lb./inch width	MD	10.2	14.1	11.2	11.2	15.7	14.1
	CD	7.3	9.7	8.1	8.1	10.9	9.9

TABLE IV (cont'd)

Sample description - all samples are surface sized and calendered		Three-ply Samples		3-ply broke in liners	broke in liners + mid-ply	3-ply 50% mid-ply	3-ply 64% mid-ply
Tensile, % wet/dry	MD	15.0	15.8	14.4	15.4	17.2	16.5
	CD	17.4	18.6	18.2	17.7	21.3	19.5
Wet stretch, %	MD	4.24	4.41	3.68	4.03	4.29	3.76
	CD	7.89	8.24	8.49	7.97	8.4	7.82
Wet TEA, ft.lb./sq.in.	MD	3.56	5.10	3.37	3.72	5.08	4.23
	CD	4.27	6.00	5.06	4.83	6.86	5.64
Wet extensional stiffness, lb./in.	MD	560	715	702	670	695	793
	CD	206	271	222	242	306	288
Internal bond, ft.lb./sq.in.	MD	0.049	0.052	0.055	0.058	0.052	0.065
	CD	0.049	0.048	0.055	0.055	0.052	0.063
Z-direction tensile, ft.lb./sq.in.		18.9	12.7	17.7	19.4	10.8	17.9
MIT fold, number of double folds	MD	485	955	446	446	548	489
	CD	223	496	178	202	264	146
Cracking, % not cracked	TS	100	100	100	100	100	100
	WS	100	100	100	100	100	99
I.G.T. blister, #4 ink, ft./min.	TS	2910	3004	3035	1609	2557	3981
	WS	2764	1280	1143	1627	1426	584
Cobb size, 2 min., gm./sq.m.	TS	31	28	30	29	30	29
	WS	34	28	29	29	31	33
Edge abs., 1% lactic acid, 40'F.-24 hr.		1.0	1.5	1.2	1.4	1.9	2.5
Edge abs. skim milk, 40'F-72 hr.		1.6	2.3	1.9	2.0	2.4	2.5

TABLE V

Sample Description		Single-Ply Samples Run at 0.72 - 0.81 headbox consistency Low Weight Range	Single-ply Samples Run at 0.72 - 0.81 headbox consistency High Weight Range	Three-ply Light Weight Samples	Three-ply Heavy Weight Samples
Basis Weight, lb./3000 sq. ft.		178.7	251.7	166.9	221.8
Caliper, 0.001 inch		18.9	25.4	17.5	24.1
Apparent density, lb./point of caliper		9.43	9.91	9.56	9.23
Tensile, lb./inch width	MD	47	69	61	78
	CD	34	47	39	49
Breaking length, M.	MD	2878	3011	4014	3903
	CD	2056	2067	2562	2457
sq. rt. (MD x CD)		2430	2494	3202	3096
Tensile ratio, MD/CD		1.40	1.46	1.59	1.60
TEA, ft. lb./sq. ft.	MD	4.78	9.86	9.27	12.03
	CD	6.88	10.92	10.80	13.51
TEA, index, ft. lb./lb.	MD	82	118	169	166
	CD	114	132	194	184
sq. rt. (MD x CD)		96	125	181	175
TEA ratio, MD/CD		0.74	0.90	0.88	0.90
Stretch, %	MD	1.44	1.9	2.03	2.05
	CD	2.47	2.73	3.20	3.20
Internal bond, ft. lb./sq. in.		0.071	0.082	0.058	0.05
STFI compression, N/15mm	MD	80.3	111.1	87.4	118.2
	CD	62.5	87.0	61.6	86.5
STFI compression index Nm/g	MD	18.4	18.1	20.6	20.4
	CD	14.3	14.2	14.5	14.9
sq. rt. (MD x CD) Nm/g		16.2	16.1	17.3	17.4
STFI compression ratio, MD/CD		1.29	1.28	1.42	1.37
Taber stiffness, gm. cm	MD	138	316	144	363
	CD	84	199	81	208
sq. rt. (MD x CD)		108	251	108	275
Stiffness ratio, MD/CD		1.65	1.60	1.78	1.73

TABLE V (cont'd)

Sample Description		Single-Ply Samples Run at 0.72 - 0.81 headbox consistency Low Weight Range	Single-ply Samples Run at 0.72 - 0.81 headbox consistency High Weight Range	Three-ply Light Weight Samples	Three-ply Heavy Weight Samples
Specific bending force					
gm.cm/basis weight	MD	0.76	1.24	0.84	1.55
	CD	0.46	0.77	0.47	0.90
sq. rt. (MD x CD)		0.59	0.98	0.63	1.18
Bendtsen smoothness ml./min.	TS	2140	2380	2213	2328
	WS	1997	2260	1990	2258
Porosity, ml/min.		1223	857	620	614
Cobb sizing, gm./sq.m.	TS	23	21	23	31
	WS	22	21	25	31
Tensile stiffness, lb./in.	MD	972	1214	1099	1295
	CD	659	860	688	821

TABLE VI

Sample Description		Secondary Headbox Consistency 3-ply 0.70% Consy.	3-ply 0.98% Consy.	3-ply 1.13% Consy.	Ply Weight % Top 25% Mid 50% Bot 25%	Top 18% Mid 64% Bot 18%
Basis Weight, lb./3000 sq. ft.		272.6	276.9	275.1	277.5	286.1
Caliper, 0.001 inch		32.9	32.8	32.9	31.6	31.3
Apparent density, lb./point of caliper		8.29	8.45	8.36	8.79	9.15
Tensile, lb./inch width	MD	82	81	74	81	77
	CD	55	50	49	42	44
Breaking length, M.	MD	3291	3199	2970	3213	2965
	CD	2232	1991	1945	1671	1704
sq. rt. (MD x CD)		2710	2524	2404	2317	2248
Tensile ratio, MD/CD		1.47	1.61	1.53	1.92	1.74
TEA, ft. lb./sq. ft.	MD	15.36	15.08	11.95	10.35	8.59
	CD	14.93	11.00	10.98	10.55	12.27
TEA, index, ft. lb./lb.	MD	169	163	130	112	90
	CD	164	119	120	114	129
sq. rt. (MD x CD)		167	140	125	113	108
TEA ratio, MD/CD		1.03	1.37	1.09	0.98	0.70
Stretch, %	MD	2.42	2.42	2.13	1.77	1.64
	CD	3.08	2.59	2.64	2.89	3.22
Internal Bond, ft. lb./sq. in.		0.049	0.053	0.051	0.041	0.058
STFI compression, N/15 mm	MD	115.8	111.3	115.2	110.6	110.6
	CD	94.8	92.3	89.0	79.4	78.6
STFI compression index Nm/g	MD	17.4	16.4	17.2	16.3	15.8
	CD	14.2	13.6	13.2	11.7	11.2
sq. rt. (MD x CD) Nm/g		15.7	15.0	15.1	13.8	13.3
STFI compression ratio, MD/CD		1.22	1.20	1.30	1.39	1.41
Taber stiffness, gm. cm	MD	576	618	604	581	624
	CD	361	366	382	316	269
sq. rt. (MD x CD)		456	475	481	428	410
Stiffness ratio, MD/CD		1.59	1.69	1.58	1.84	2.31

TABLE VI (cont'd)

Sample Description		Secondary Headbox Consistency: 3-ply 0.70% Consy.	3-ply 0.98% Consy.	3-ply 1.13% Consy.	Ply Weight %: Top 25% Mid 50% Bot 25%	Top 18% Mid 64% Bot 18%
Specific bending force gm.cm/basis weight	MD	2.11	2.23	2.20	2.09	2.18
	CD	1.32	1.32	1.39	1.14	0.94
sq. rt. (MD x CD)		1.67	1.72	1.75	1.54	1.43
Bendtsen smoothness ml./min.	TS	2710	2675	2935	1870	2185
	WS	2760	2565	2680	2035	1995
Porosity, ml./min.		810	735	770	750	730
Cobb sizing, gm./sq.m.	TS	22	23	21	21	24
	WS	23	22	21	20	20
Tensile stiffness, lb./in.	MD	1265	1223	1244	1377	1312
	CD	865	879	826	755	731

Paper board manufactured in accordance with the present invention was converted to quart-size and half-gallon-size milk cartons and tested. Prior to its conversion, boards having a basis weight of 180, 200 and 220 lb/3000 ft^2 were passed through an extruder and coated with about 16.7 lb of matte polyethylene on the outer surface of the third layer of the boards and about 10.7 lb. of gloss polyethylene on the outer surface of the first (wire) layer of the boards. Boards having a basis weight of 250 and 280 lb/3000 ft^2 were coated with 18.9 lb. of matte PE on their third layer surfaces and 11.1 lb of gloss PE on their wire sides. The results of testing of converted milk cartons are given in Tables VII and VIII. These data show that the cartons made from the multiply board of the present invention compared favorably to like cartons made

from single ply board.

TABLE VII

QUART CARTONS

Sample Description		----- single ply ----- 0.75 to 0.85% headbox consistency		--- single ply --- 0.65% consistency	----- three ply ----- Run 1	Run 2
Carton Caliper, 0.001 inch		18.6	21.0	19.4	18.5	21.5
Carton weight, lb./1000 cartons		65.6	74.2	68.5	63.1	72.4
Film weight, lb./3000 sq. ft. average	MS	16.4	16.4	17.0	17.9	16.7
average	GS	9.6	10.2	10.9	10.9	11.8
Base stock caliper, 0.001 in.		16.8	19.1	17.5	16.5	19.5
Base stock weight, lb./3000 sq. ft.		194.1	222.4	201.9	182.9	214.6
Base stock apparent density, lb./pt.		11.5	11.6	11.5	11.1	11.0
Sheffield smoothness, units	MS	285	295	293	292	291
	GS	184	217	179	164	215
Taber V-5 stiffness, gm.cm.	MD	173	219	211	195	274
	CD	102	122	114	96	143
Internal bond, ft. lb./sq. in.	MD	0.080	0.084	0.093	0.049	0.044
	CD	0.070	0.091	0.091	0.046	0.042
Tensile, lb./in. width	MD	71.8	88.7	91.1	73.4	81.5
Tensile wet, lb./in. width	MD	15.9	18.0	22.2	16.8	19.2
Tensile percent wet/dry		22.3	20.4	24.4	22.9	23.5
Edge absorption, gm.100 lin. in.						
1% lactic acid, 40°F-24 hr.		1.1	1.2	1.2	1.0	1.2
water, 73°F-72 hr.		3.0	3.3	3.2	2.8	3.2
skim milk, 40°F-72 hr.		1.7	2.0	1.8	1.7	2.1
orange juice, 40°F-72 hr.		1.9	1.9	1.8	2.2	3.4
apple juice, 40°F-72 hr.		1.6	1.9	1.7	1.6	1.9
Edge wicking						
aerosol-rhod., 73°F-30 sec.		3.0	3.8	5.1	3.9	4.0
alcohol-methylene, 73°F-30 sec.		17.7	18.5	18.4	21.3	22.8
phos. acid, 180°F-10 min.		1.0	1.0	2.3	1.0	1.0
phos. acid, 73°F-72 hr.		3.0	2.8	3.2	3.0	3.0
20% lactic acid 100°F-15 min.	MS	1.0	1.0	1.0	1.0	1.0
	GS	1.0	1.0	1.0	1.0	1.0

TABLE VII (cont'd)

Sample Description	----- single ply ----- 0.75 to 0.85% headbox consistency		--- single ply --- 0.65% consistency	----- three ply -----	
				Run 1	Run 2
Score height					
bottom horizontal, 0.001 in.	0.7	1.2	1.1	0.4	0.7
Cracking, bot. horz. score, 180 flex	0	0	0	0	0
Cracking, whole carton (low best) MS	1	1	2	1	2
NBC SPRGBK, No. 2 vert. scr. gm.cm/in.	113.2	133.3	131.2	111.1	130.0
NBC springback index	1.6	1.6	1.6	1.8	2.1
Bottom heat activated defects					
temperature normal	1000	1000	1000	1000	1000
bottom score-cuts	1	1	1	1	1
bottom score-cracks	1	1	1	1	1
bottom score-pinholes	1	1	1	1	1
bottom panels-pinholes	2	2	2	2	2
temperature normal + 200	1200	1200	1200	1200	1200
bottom score-cuts	1	1	1	1	1
bottom score-cracks	1	1	1	1	1
bottom score-pinholes	1	1	1	1	1
bottom panels-pinholes	5	4	5	5	4
Bulge with skim milk at 40°F					
1/32 inch day 0	1.9	1.0	1.7	1.9	1.5
day 3	8.4	6.3	6.8	8.0	6.0
day 7	9.9	8.2	8.7	10.0	7.5
day 14	12.7	11.0	11.5	12.3	10.0
Durability with homogenized milk 1 day storage					
leaks/10 cartons after 60 min.	3.1	1.2	1.5	3.8	2.5
leaks/10 cartons after 120 min.	10.3	6.8	6.8	12.1	8.8

TABLE VIII

HALF GALLON CARTONS

Sample Description		single ply 0.8% consistency	three ply	three ply 50% mid-ply	three ply 64% mid-ply
Carton Caliper, 0.001 inch		25.9	25.8	26.9	28.0
Carton weight, lb./1000 cartons		139.2	129.2	137.0	140.0
Film weight, lb./3000 sq. ft. average	MS	17.9	19.5	18.6	19.0
average	GS	10.6	11.9	11.8	11.7
Base stock caliper, 0.001 in.		23.9	23.6	24.8	25.9
Base stock weight, lb./3000 sq. ft.		282.2	257.1	275.5	281.9
Base stock apparent density, lb./pt.		11.8	10.9	11.1	10.9
Sheffield smoothness, units	MS	292	304	300	317
	GS	321	243	229	254
Taber V-5 stiffness, gm.cm.	MD	430	438	523	478
	CD	255	239	279	258
Internal bond, ft. lb./sq. in.	MD	0.083	0.052	0.050	0.063
	CD	0.079	0.046	0.057	0.077
Tensile, lb./in. width	MD	86.8	93.5	108.8	94.8
Tensile wet, lb./in. width	MD	16.3	20.5	23.8	22.1
Tensile percent wet/dry		18.8	22.0	21.8	23.4
Edge absorption, gm.100 lin. in.					
1% lactic acid, 40°F-24 hr.		1.6	1.6	1.7	2.0
water, 73°F-72 hr.		4.2	4.1	4.4	6.8
skim milk, 40°F-72 hr.		2.8	3.3	4.2	4.3
orange juice, 40°F-72 hr.		2.7	2.7	3.4	4.2
apple juice, 40°F-72 hr.		2.4	2.6	2.8	3.0
Edge wicking					
aerosol-rhod., 73°F-30 sec.		3.4	2.9	3.8	4.8
alcohol-methylene, 73°F-30 sec.		12.5	14.4	16.0	16.4
phos. acid, 180°F-10 min.		2.6	2.6	2.3	3.6
phos. acid, 73°F-72 hr.		2.9	2.9	2.6	3.9
20% lactic acid 100°F-15 min.	MS	1.0	1.0	1.0	1.5
	GS	1.0	1.0	1.0	1.5

TABLE VIII (cont'd)

Sample Description	single ply 0.8% consistency	three ply	three ply 50% mid-ply	three ply 64% mid-ply
Score height				
bottom horizontal, 0.001 in.	4.5	3.7	5.2	4.4
Cracking, bot. horz. score, 180 flex	0	0	0	0.5
Cracking, whole carton (low best) MS	2	1.5	2	2
NBC SPRGBK, No. 2 vert. scr. gm.cm/in.	198.8	176.3	206.3	217.5
NBC springback index	2.2	2.5	2.5	2.2
Bottom heat activated defects				
temperature normal	1100	1100	1100	1100
bottom score-cuts	1	1	1	1
bottom score-cracks	1	1	1	1
bottom score-pinholes	1	1	1	2
bottom panels-pinholes	2	2	2	2
temperature normal + 200	1225	1225	1225	1225
bottom score-cuts	1	1	1	1
bottom score-cracks	1	1	1	1
bottom score-pinholes	1	1	1	1
bottom panels-pinholes	4	3	3	3
Bulge with skim milk at 40°F				
1/32 inch day 0	2.2	2.3	3.2	3.0
day 3	12.2	12.0	1.2	10.7
day 7	14.7	14.6	14.5	12.5
day 14	16.7	16.7	16.3	15.3
Durability with homogenized milk 1 day storage				
leaks/10 cartons after 60 min.	6.0	3.2	2.3	0.8
leaks/10 cartons after 120 min.	11.5	7.1	5.6	3.3

Claims

1. A method for the manufacture of a board suitable for use in the fabrication of a container for liquid food products comprising the steps of:

    forming first and second slurries of cellulosic fibers in a flowable medium each slurry having a consistency of between about 0.6% and about 1.12%, by weight,

    directing said first slurry onto a foraminous forwardly moving papermaking forming fabric to develop a first layer of fibers on said fabric,

    substantially simultaneously directing said second slurry onto the exposed surface of said first layer of fibers on said fabric to develop a second layer of fibers on said first layer of fibers on said fabric, the quantity of fibers deposited from said second slurry onto said fabric being between about 0% and about 300% greater than the quantity of fibers deposited on said fabric from said first slurry,

partially dewatering said first and second layers on said fabric to a consistency of between about 1.8% and about 3.5% by weight to form a bilayered web on said fabric, and thereupon mechanically integrating said first and second layers of said bilayered web and conditioning the upper surface of said second layer for receiving a third layer of fibers,

substantially immediately downstream of the wet line of said bilayered web on said fabric, directing a further slurry of fibers onto the exposed surface of said second layer to develop a third layer of fibers on said fabric to form a trilayered web on said fabric,

substantially immediately downstream of the deposition of said further slurry of fibers, capturing said trilayered web on said fabric between said fabric and a further foraminous fabric, and

withdrawing liquid through said further fabric to partially dry said web and hydraulically integrate said second and third layers at their interface.

2. The method of Claim 1 wherein said first and further slurries of fibers are substantially identical in composition.

3. The method of Claim 1 and including the step of applying a surface size to said web.

4. The method of Claim 1 and including the further step of applying a coating of polymeric material to the exposed surfaces of said web.

5. The method of Claim 1 wherein the board product has a stiffness ratio of at least about 1.80 and a mean stiffness of at least about 110.

6. Apparatus for the manufacture of a cellulosic board suitable for use in the fabrication of containers for liquid food products comprising

a first foraminous forming fabric,

means mounting said forming fabric and moving the same in a forward direction and defining a run thereof,

a source of a first slurry of cellulosic fibers disposed in a flowable medium,

means depositing a stream of said first slurry of fibers onto said run of said fabric to develop a first layer of fibers on said fabric,

a source of a second slurry of cellulosic fibers disposed in a flowable medium,

means depositing a stream of said second slurry of fibers onto said first layer of fibers substantially simultaneously with the deposition of said first layer of fibers, and developing a second layer of fibers on said first layer of fibers, and including means controlling the quantity of said second slurry deposited onto said first layer such that there is deposited onto said first layer a quantity of fibers of between about 0% and about 300% greater than the quantity of fibers deposited by said first slurry onto said fabric,

means for withdrawing liquid from said layer of fibers on said fabric through said forming fabric to form said first slurry of fibers into a web on said forming fabric, whereby there is developed a bilayered web on said fabric,

means for mechanically integrating said first and second layers of fibers on said fabric and conditioning said second layer of fibers for receiving a third layer of fibers thereon, said means being located downstream of said means for depositing said fibers onto said fabric a distance sufficient to permit said liquid withdrawal to proceed to the extent that the combined consistency of said first and second layers of fibers is between about 1.8% and 3.5% by weight,

a source of a third slurry of cellulosic fibers,

means depositing a stream of said third slurry onto the exposed surface of said second layer of fibers on said fabric to develop a third layer of fibers on said first fabric, said means being located substantially immediately downstream of the wet line of the bilayered web on said first fabric,

further foraminous fabric means including a run disposed in substantially parallel relationship to said first fabric and in contact with the exposed surface of said third layer of fibers on said first fabric,

means disposed on that side of said further fabric opposite said first fabric for withdrawing liquid from said fibrous layers on said first fabric and hydraulically integrating said second and third layers of fibers to establish a trilayered web on said first fabric.

7. A paper board useful in the fabrication of containers for liquid food products manufactured in accordance with the method of any of Claims 1 through 6.

8. A container for liquid food products comprising a cellulosic fiber board including at least three layers integrally bonded one to another to the extent that their interbond strength equals or exceeds the internal bond strength of either of the individual layers of the board and the board exhibits a caliper and overall strength equal to or exceeding the caliper and overall strength of a single ply board containing between 9% and 11% more fibrous content than said three-layered board.

9. A planar sheet of base stock for use in production of a disposable container for liquid food products, and particularly for milk and milk-based products, comprising

a first layer of cellulosic fibers formed by the deposition of a slurry of said fibers in a flowable medium at a consistency of between about 0.6% and about 1.12% onto a papermaking forming fabric, said fibers comprising between about 70% and 80% hardwood fibers and between about 20% and 30% softwood fibers, by weight,

a second layer of cellulosic fibers formed by the substantially simultaneous deposition of a slurry of said fibers in a flowable medium at a consistency of between about 0.6% and 1.12% onto said first layer of fibers on said forming fabric, said fibers comprising between about 20% and 30% hardwood fibers and between about 70% and 80% softwood fibers, by weight, said first and second layer of fibers being mechanically integrated at least at their layer interface after their respective fiber consistencies have been increased to between about 2% and 3.5%, by weight,

a third layer of cellulosic fibers of substantial identity as the fibers of said first layer formed by the deposition of a slurry of said fibers onto said second layer after said combined first and second layers have passed the wet line of said papermaking forming fabric, said third layer of fibers being hydraulically integrated with said fibers of said second layer at their layer interface, said layers thereafter being further dewatered and dried,

said layers being surface sized with a coating pickup of between about 2.3 to about 3.9 lb./3000 ft^2, and thereafter calendered,

a layer of polymeric material bonded to the opposite flat surfaces of said sheet,

wherein said sheet exhibits a basis weight between about 160 and about 210 1b./3000 ft^2, a caliper of between about 0.014 and about 0.025 inch, a stiffness ratio of not less than about 1.80, a mean stiffness of at least about 110, an interlayer bonding strength that exceeds the internal bonding strength of said layers, a Sheffield porosity of between about 100 and about 250 units/in^2, a tensile strength of between about 55 and about 100 lb/inch width, and an MIT fold of between about 350 and about 1250 double folds.

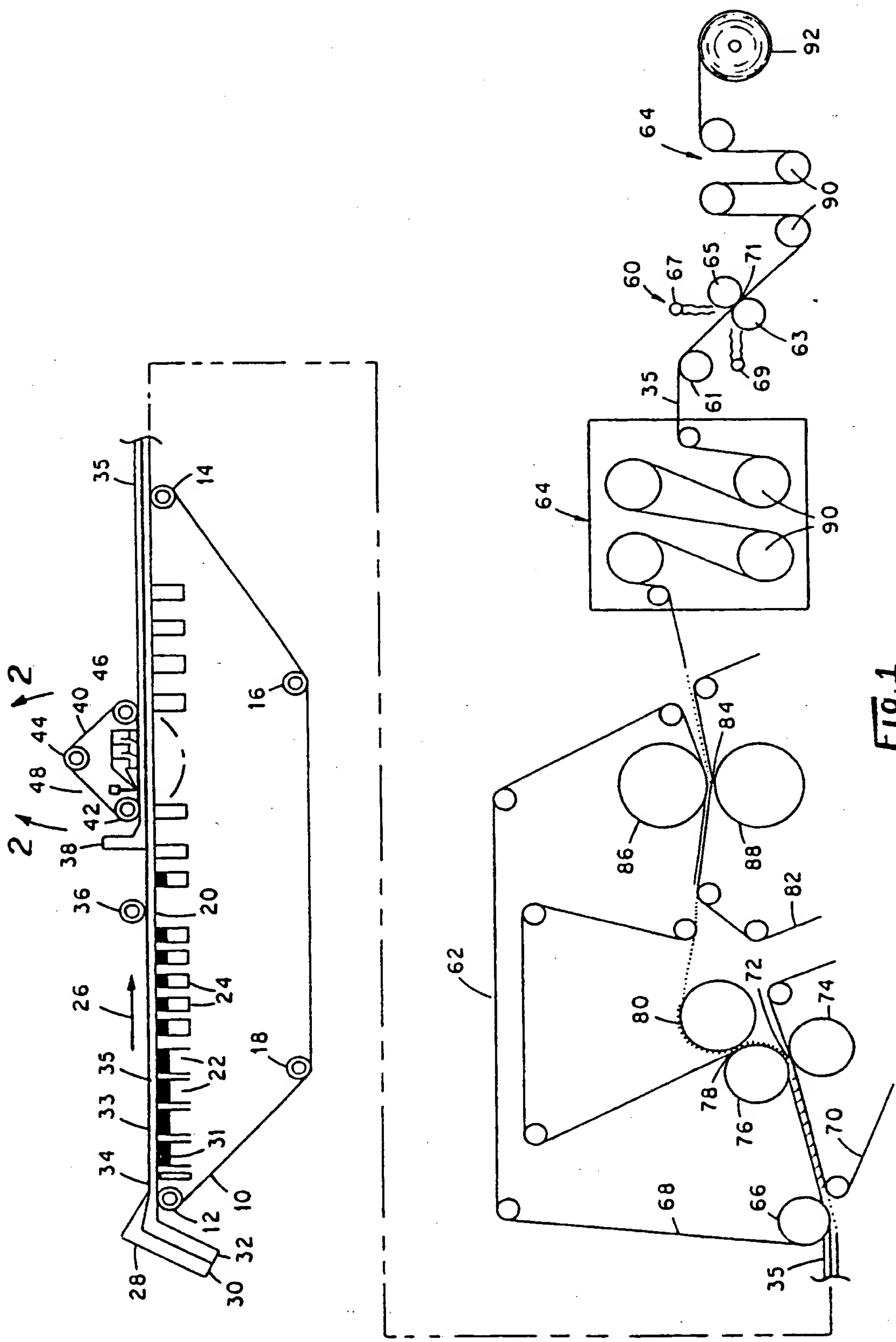
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Fig. 1

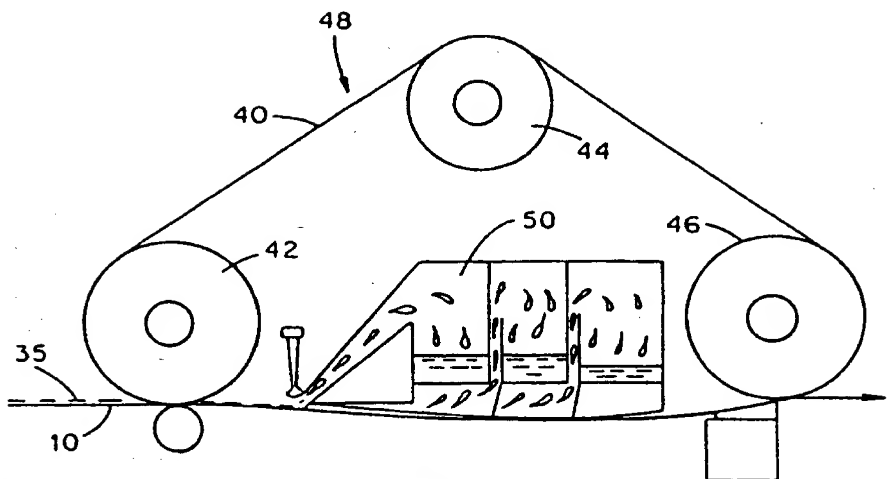

Fig. 2

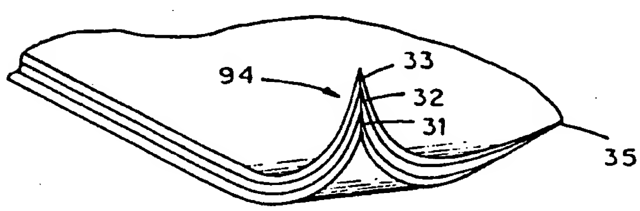

Fig. 3